a positioning system to position the SPM modification probe with respect to the object; and

a controller to control the positioning system such that (1) the modification of the object is made with the SPM probe and particulate material is removed from the object due to the modification, and (2) the SPM probe makes sweeping motions over the object to sweep the particulate material away.

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2. An SPM system as recited in claim 1 further comprising:

inspection components to make an inspection of the modification; the sweeping motions of the SPM probe sweeping the debris material away from where the modification was made so that the inspection components may inspect the modification without obstruction.

3. An SPM system as recited in claim 2 wherein:

the inspection components include a second ~~SPIVI~~ SPM probe to make the inspection; the positioning system positions the second ~~SPIVI~~ SPM probe with respect to the object; and the controller further controls the positioning system such that the inspection is made with the second SPM probe.

4. An SPM system as recited in claim 2 wherein:

the inspection components include the SPM probe; and the controller further controls the positioning system such that the inspection is made with the SPM probe.

B1 1. ~~/8--91.~~ A scanning probe microscopy system for working with an object having a work surface, comprising:

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a movable scanning head having a seat therein;

a probe mounted in the seat, the probe comprising:

a probe base having a probe surface oriented toward the work surface of the object, the probe surface having a first aperture therein; and

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a probe tool mounted in the first aperture and configured to interact with the object; and

B1 cont.

means for restricting gas flow into a region between the probe surface and the work surface of the object so that when the first aperture is placed in fluid communication with a vacuum source, a microvacuum chamber is formed in a gap region surrounding the first aperture and extending between the probe surface and the work surface of the object.

2 ~~92~~. The system of claim 1 ~~91~~, wherein the means for restricting gas flow comprises a conformal seal mounted on the probe surface with an edge of the conformal seal surrounding the first aperture.

3 ~~93~~. The system of claim 1 ~~91~~, wherein the means for restricting gas flow comprises a conformal seal mounted on the scanning head with the conformal seal surrounding the seat.

4 ~~94~~. The system of claim 1 ~~91~~, wherein the means for restricting gas flow comprises:

a gap sensor system configured to determine a gap width between the probe surface and the work surface; and

a gap adjustment mechanism, responsive to the gap sensor system, configured to maintain the gap width at a value sufficient to allow a zone of substantially reduced pressure to be formed in a gap region centered on the first aperture and extending between the probe surface and the work surface when a vacuum source is operated in fluid communication with the first aperture.

5 ~~95~~. The system of claim 4 ~~94~~, wherein the probe tool comprises a cantilever and the cantilever is used in the gap sensor system to determine the gap width.

6 ~~96~~. The system of claim 4 ~~94~~, wherein the gap sensor system comprises:

a cantilevered tip mounted in a recess in the probe surface and configured to be deflected by an amount that varies with a distance between the cantilevered tip and the work surface of the object; and

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B1 cont

an electrostatic sensor configured to detect an amount of deflection of the cantilevered tip.

7 ~~11~~ ~~97~~. The system of claim ~~94~~ 84, wherein the object is a conductive object and the gap sensor system comprises:

an insulating plate mounted on the probe surface; and

a plate electrode mounted on the insulating plate,

wherein a voltage between the plate electrode and the conductive object is detected and used to determine the gap distance.

8 ~~12~~ ~~98~~. The system of claim ~~94~~ 84, wherein the gap adjustment mechanism comprises:

an annular outlet in the probe surface;

an inlet in a surface of the probe base other than the probe surface; and

a duct connecting the annular outlet to the inlet,

wherein the gap distance is adjusted by controlling a pressure of a gas flowing into the inlet, through the duct, and out of the annular outlet.

9 ~~13~~ ~~99~~. The system of claim ~~94~~ 84, wherein the gap adjustment mechanism comprises:

a plurality of outlets in the probe surface surrounding the first aperture;

a corresponding plurality of inlets in a surface of the probe base other than the probe surface; and

a corresponding plurality of ducts, each duct connecting one of the outlets to a respective one of the inlets,

wherein the gap distance is adjusted by independently adjusting a pressure of a gas flowing into each of the inlets, through the respective duct, and out through the respective outlet.

10 ~~14~~ ~~100~~. The system of claim ~~94~~ 84, wherein the gap adjustment mechanism comprises:

a first annular outlet in the probe surface surrounding the first aperture;

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an annular inlet in the probe surface surrounding and substantially concentric with the first annular outlet;

B1 cont'

a second annular outlet in the probe surface surrounding and substantially concentric with the annular inlet;

a first remote inlet in a surface of the probe base other than the probe surface, the first remote inlet connected to the first annular outlet by a first duct;

a second remote inlet in a surface of the probe base other than the probe surface, the second remote inlet connected to the second annular outlet by a first duct; and

a remote outlet in a surface of the probe base other than the probe surface, the remote outlet connected to the annular inlet by a third duct,

wherein the probe surface is stepped such that a distance between the first annular outlet and the work surface is less than a distance between the annular inlet and the work surface, and the distance between the annular inlet and the work surface is less than a distance between the second annular outlet and the work surface,

wherein adjustment of the gap width is provided by regulating the flow of a low pressure, high viscosity first gas through the first remote inlet to the first annular outlet,

wherein loose material is removed from the object by the flow of a high pressure low viscosity second gas through the second remote inlet the second annular outlet, and

wherein the annular inlet draws both the first gas and the second gas away from the work surface when the remote outlet is connected to a vacuum source.

11 ~~18~~ ~~101~~. The system of claim 84 ~~94~~, wherein the gap adjustment mechanism comprises a plurality of displacement transducers in the seat of the scanning head for moving the probe surface relative to the seat along a line substantially normal to the work surface of the object, thereby adjusting the gap width.

12 ~~15~~ ~~102~~. The system of claim 81 ~~91~~, further comprising a vacuum source in fluid communication with the first aperture.

13 ~~17~~ ~~103~~. The system of claim ~~16~~ 12 ~~102~~, wherein the vacuum source comprises:

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B1 cont.

a vacuum pump; and

a large vacuum chamber in fluid communication with the vacuum pump and with the first aperture.

14 ~~18~~ ~~104~~. The system of claim ~~16~~ 10 ~~102~~, wherein the vacuum source comprises a vacuum pump within the probe base.

15 ~~19~~ ~~105~~. The system of claim ~~18~~ 14 ~~104~~, wherein the vacuum pump comprises:

a pumping control circuit;

a pumping chamber within the probe base, the pumping chamber having a movable membrane wall and an inlet in a wall other than the membrane wall;

an outlet in a surface of the probe base other than the probe surface, the outlet connected to the pumping chamber;

an outlet valve controlled by the pumping control circuit, the outlet valve disposed between the pumping chamber and the outlet; and

a plate electrode located in the probe base outside the pumping chamber and oriented toward the membrane wall, the plate electrode controlled by the pumping control circuit,

wherein at a first time, the outlet valve is closed and the plate electrode moves the membrane wall to expand the pumping chamber, and at a second time, the outlet valve is opened and the plate electrode moves the membrane wall to contract the pumping chamber.

16 ~~20~~ ~~106~~. The system of claim ~~51~~ 1 ~~91~~, wherein when the first aperture is placed in fluid communication with a gas source, a microdifferential pressure chamber is formed in the gap region.

17 ~~21~~ ~~107~~. The system of claim ~~51~~ 1 ~~91~~, wherein the probe tool comprises a particle beam tool.

18 ~~22~~ ~~108~~. The system of claim ~~21~~ 17 ~~107~~, wherein the particle beam is an electron beam.

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19 ~~23~~ ~~109~~. The system of claim ~~21~~ 17 ~~107~~, wherein the particle beam is an ion beam.

20 ~~24~~ ~~110~~. The system of claim ~~5~~ 1 ~~91~~, wherein the probe tool comprises a vacuum arc tool.

21 ~~25~~ ~~111~~. A particle beam tool for measuring and modifying an object, comprising:

a probe base having a probe surface oriented toward a work surface of the object, the probe surface having a first aperture therein;

a particle beam emitter suspended in the first aperture;

an accelerating electrode located within the first aperture and below the particle beam emitter, the accelerating electrode having an aperture allowing a particle beam from the particle beam emitter to pass;

a plurality of steering electrodes located within the aperture and below the accelerating electrode, the steering electrodes operable to control a direction of the particle beam and arranged to provide an aperture allowing the particle beam to pass;

a collecting electrode within the aperture and below the steering electrode, the collecting electrode having an aperture allowing the particle beam to pass;

a control circuit configured to operate the particle beam emitter to emit a particle beam, to operate the plurality of steering electrodes to direct the particle beam, and to operate the collecting electrode to collect particles reflected from the object; and

means for restricting gas flow into a region between the probe surface and the work surface of the object so that when the first aperture is placed in fluid communication with a vacuum source, a microvacuum chamber is formed in a gap region centered on the first aperture and extending between the probe surface and the work surface of the object.

22 ~~26~~ ~~112~~. The system of claim ~~25~~ 21 ~~111~~, wherein the particle beam is an electron beam.

23 ~~27~~ ~~113~~. The system of claim ~~25~~ 21 ~~111~~, wherein the particle beam is an ion beam.

24 ~~28~~ ~~114~~. The system of claim ~~25~~ 21 ~~111~~, further comprising:

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a plurality of steering magnets fixed to the probe surface and disposed around the first aperture, wherein selectively applying currents to the plurality of steering magnets causes the particle beam to be steered in a selected direction.

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25 ~~29~~ ~~115~~. The system of claim ~~111~~ ~~25~~ 21, further comprising:

a steering coil surrounding the first aperture, wherein selectively applying a current causes the particle beam to be steered in a spiral trajectory.

26 ~~30~~ ~~116~~. The system of claim ~~115~~ ~~29~~ 25, wherein the steering electrodes, steering magnets, and steering coil together are operable to steer the particle beam into a surface of the object not substantially parallel to the work surface.

~~31~~ ~~117~~. A vacuum arc tool for modifying an object, comprising:

a probe base having a probe surface oriented toward a work surface of the object, the probe surface having a first aperture therein;

a support platform suspended in the first aperture;

a first plate electrode mounted on the support platform within the first aperture and oriented toward the work surface;

a second plate electrode mounted on the support platform and suspended over the first plate electrode within the first aperture, the second plate electrode having an aperture therein;

a first outlet for fluid material in the support platform in proximity to the first plate electrode, the first outlet oriented toward the work surface;

a control circuit configured to cause a fluid material to flow through the outlet into the space between the electrodes and to apply an opposite charge to the first and second plate electrodes, thereby inducing the fluid material to flow toward the object; and

means for restricting gas flow into a region between the probe surface and the work surface of the object so that when the first aperture is placed in fluid communication with a vacuum source, a microvacuum chamber is formed in a gap region centered on the first aperture and extending between the probe surface and the work surface of the object.

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~~118~~. The vacuum arc tool of claim ~~117~~, further comprising:

a second outlet in the support platform at a location removed from the first plate electrode, the second outlet oriented toward the work surface,

wherein the control circuit is further configured to cause a fluid material to flow through the second outlet into the space between the second electrode and the object.

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~~119~~. A material removal system for removing loose material from an object, the material removal system comprising:

a probe surface oriented toward a surface of the object;

a first annular outlet in the probe surface;

an annular inlet in the probe surface surrounding and substantially concentric with the first annular outlet;

a second annular outlet in the probe surface surrounding and substantially concentric with the annular inlet;

a first remote inlet in a surface of the probe base other than the probe surface, the first remote inlet connected to the first annular outlet by a first duct;

a second remote inlet in a surface of the probe base other than the probe surface, the second remote inlet connected to the second annular outlet by a first duct; and

a remote outlet in a surface of the probe base other than the probe surface, the remote outlet connected to the annular inlet by a third duct,

wherein the probe surface is stepped such that a distance between the first annular outlet and the work surface is less than a distance between the annular inlet and the work surface, and the distance between the annular inlet and the work surface is less than a distance between the second annular outlet and the work surface,

wherein a low pressure, high viscosity first gas flows through the inner annular outlet toward the object surface, thereby creating a gas bearing and sealing off a region of the probe surface surrounded by the first annular outlet,

wherein a high pressure, low viscosity second gas flows through the outer annular outlet toward the object surface, displacing the loose material, and

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APPENDIX OF PENDING CLAIMS

1. An SPM system for making a modification to an object, the SPM system comprising:

an SPM probe for making a modification to the object;

a positioning system to position the SPM modification probe with respect to the object; and

a controller to control the positioning system such that (1) the modification of the object is made with the SPM probe and particulate material is removed from the object due to the modification, and (2) the SPM probe makes sweeping motions over the object to sweep the particulate material away.

2. An SPM system as recited in claim 1 further comprising:

inspection components to make an inspection of the modification; the sweeping motions of the SPM probe sweeping the debris material away from where the modification was made so that the inspection components may inspect the modification without obstruction.

3. An SPM system as recited in claim 2 wherein:

the inspection components include a second SPIVI probe to make the inspection; the positioning system positions the second SPIVI probe with respect to the object; and the controller further controls the positioning system such that the inspection is made with the second SPM probe.

4. An SPM system as recited in claim 2 wherein:

the inspection components include the SPM probe; and the controller further controls the positioning system such that the inspection is made with the SPM probe.

91. A scanning probe microscopy system for working with an object having a work surface, comprising:

a movable scanning head having a seat therein;

a probe mounted in the seat, the probe comprising:

a probe base having a probe surface oriented toward the work surface of the object, the probe surface having a first aperture therein; and

a probe tool mounted in the first aperture and configured to interact with the object; and

means for restricting gas flow into a region between the probe surface and the work surface of the object so that when the first aperture is placed in fluid communication with a vacuum source, a microvacuum chamber is formed in a gap region surrounding the first aperture and extending between the probe surface and the work surface of the object.

92. The system of claim 91, wherein the means for restricting gas flow comprises a conformal seal mounted on the probe surface with an edge of the conformal seal surrounding the first aperture.

93. The system of claim 91, wherein the means for restricting gas flow comprises a conformal seal mounted on the scanning head with the conformal seal surrounding the seat.

94. The system of claim 91, wherein the means for restricting gas flow comprises:

a gap sensor system configured to determine a gap width between the probe surface and the work surface; and

a gap adjustment mechanism, responsive to the gap sensor system, configured to maintain the gap width at a value sufficient to allow a zone of substantially reduced pressure to be formed in a gap region centered on the first aperture and extending between the probe surface and the work surface when a vacuum source is operated in fluid communication with the first aperture.

95. The system of claim 94, wherein the probe tool comprises a cantilever and the cantilever is used in the gap sensor system to determine the gap width.

96. The system of claim 94, wherein the gap sensor system comprises:

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a cantilevered tip mounted in a recess in the probe surface and configured to be deflected by an amount that varies with a distance between the cantilevered tip and the work surface of the object; and

an electrostatic sensor configured to detect an amount of deflection of the cantilevered tip.

97. The system of claim 94, wherein the object is a conductive object and the gap sensor system comprises:

an insulating plate mounted on the probe surface; and

a plate electrode mounted on the insulating plate,

wherein a voltage between the plate electrode and the conductive object is detected and used to determine the gap distance.

98. The system of claim 94, wherein the gap adjustment mechanism comprises:

an annular outlet in the probe surface;

an inlet in a surface of the probe base other than the probe surface; and

a duct connecting the annular outlet to the inlet,

wherein the gap distance is adjusted by controlling a pressure of a gas flowing into the inlet, through the duct, and out of the annular outlet.

99. The system of claim 94, wherein the gap adjustment mechanism comprises:

a plurality of outlets in the probe surface surrounding the first aperture;

a corresponding plurality of inlets in a surface of the probe base other than the probe surface; and

a corresponding plurality of ducts, each duct connecting one of the outlets to a respective one of the inlets,

wherein the gap distance is adjusted by independently adjusting a pressure of a gas flowing into each of the inlets, through the respective duct, and out through the respective outlet.

100. The system of claim 94, wherein the gap adjustment mechanism comprises:

a first annular outlet in the probe surface surrounding the first aperture;

an annular inlet in the probe surface surrounding and substantially concentric with the first annular outlet;

a second annular outlet in the probe surface surrounding and substantially concentric with the annular inlet;

a first remote inlet in a surface of the probe base other than the probe surface, the first remote inlet connected to the first annular outlet by a first duct;

a second remote inlet in a surface of the probe base other than the probe surface, the second remote inlet connected to the second annular outlet by a first duct; and

a remote outlet in a surface of the probe base other than the probe surface, the remote outlet connected to the annular inlet by a third duct,

wherein the probe surface is stepped such that a distance between the first annular outlet and the work surface is less than a distance between the annular inlet and the work surface, and the distance between the annular inlet and the work surface is less than a distance between the second annular outlet and the work surface,

wherein adjustment of the gap width is provided by regulating the flow of a low pressure, high viscosity first gas through the first remote inlet to the first annular outlet,

wherein loose material is removed from the object by the flow of a high pressure low viscosity second gas through the second remote inlet the second annular outlet, and

wherein the annular inlet draws both the first gas and the second gas away from the work surface when the remote outlet is connected to a vacuum source.

101. The system of claim 94, wherein the gap adjustment mechanism comprises a plurality of displacement transducers in the seat of the scanning head for moving the probe surface relative to the seat along a line substantially normal to the work surface of the object, thereby adjusting the gap width.

102. The system of claim 91, further comprising a vacuum source in fluid communication with the first aperture.

103. The system of claim 102, wherein the vacuum source comprises:

a vacuum pump; and

a large vacuum chamber in fluid communication with the vacuum pump and with the first aperture.

104. The system of claim 102, wherein the vacuum source comprises a vacuum pump within the probe base.

105. The system of claim 104, wherein the vacuum pump comprises:

a pumping control circuit;

a pumping chamber within the probe base, the pumping chamber having a movable membrane wall and an inlet in a wall other than the membrane wall;

an outlet in a surface of the probe base other than the probe surface, the outlet connected to the pumping chamber;

an outlet valve controlled by the pumping control circuit, the outlet valve disposed between the pumping chamber and the outlet; and

a plate electrode located in the probe base outside the pumping chamber and oriented toward the membrane wall, the plate electrode controlled by the pumping control circuit,

wherein at a first time, the outlet valve is closed and the plate electrode moves the membrane wall to expand the pumping chamber, and at a second time, the outlet valve is opened and the plate electrode moves the membrane wall to contract the pumping chamber.

106. The system of claim 91, wherein when the first aperture is placed in fluid communication with a gas source, a microdifferential pressure chamber is formed in the gap region.

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107. The system of claim 91, wherein the probe tool comprises a particle beam tool.

108. The system of claim 107, wherein the particle beam is an electron beam.

109. The system of claim 107, wherein the particle beam is an ion beam.

110. The system of claim 91, wherein the probe tool comprises a vacuum arc tool.

111. A particle beam tool for measuring and modifying an object, comprising:

a probe base having a probe surface oriented toward a work surface of the object, the probe surface having a first aperture therein;

a particle beam emitter suspended in the first aperture;

an accelerating electrode located within the first aperture and below the particle beam emitter, the accelerating electrode having an aperture allowing a particle beam from the particle beam emitter to pass;

a plurality of steering electrodes located within the aperture and below the accelerating electrode, the steering electrodes operable to control a direction of the particle beam and arranged to provide an aperture allowing the particle beam to pass;

a collecting electrode within the aperture and below the steering electrode, the collecting electrode having an aperture allowing the particle beam to pass;

a control circuit configured to operate the particle beam emitter to emit a particle beam, to operate the plurality of steering electrodes to direct the particle beam, and to operate the collecting electrode to collect particles reflected from the object; and

means for restricting gas flow into a region between the probe surface and the work surface of the object so that when the first aperture is placed in fluid communication with a vacuum source, a microvacuum chamber is formed in a gap region centered on the first aperture and extending between the probe surface and the work surface of the object.

112. The system of claim 111, wherein the particle beam is an electron beam.

113. The system of claim 111, wherein the particle beam is an ion beam.

114. The system of claim 111, further comprising:

a plurality of steering magnets fixed to the probe surface and disposed around the first aperture, wherein selectively applying currents to the plurality of steering magnets causes the particle beam to be steered in a selected direction.

115. The system of claim 111, further comprising:

a steering coil surrounding the first aperture, wherein selectively applying a current causes the particle beam to be steered in a spiral trajectory.

116. The system of claim 115, wherein the steering electrodes, steering magnets, and steering coil together are operable to steer the particle beam into a surface of the object not substantially parallel to the work surface.

117. A vacuum arc tool for modifying an object, comprising:

a probe base having a probe surface oriented toward a work surface of the object, the probe surface having a first aperture therein;

a support platform suspended in the first aperture;

a first plate electrode mounted on the support platform within the first aperture and oriented toward the work surface;

a second plate electrode mounted on the support platform and suspended over the first plate electrode within the first aperture, the second plate electrode having an aperture therein;

a first outlet for fluid material in the support platform in proximity to the first plate electrode, the first outlet oriented toward the work surface;

a control circuit configured to cause a fluid material to flow through the outlet into the space between the electrodes and to apply an opposite charge to the first and second plate electrodes, thereby inducing the fluid material to flow toward the object; and

means for restricting gas flow into a region between the probe surface and the work surface of the object so that when the first aperture is placed in fluid communication with a vacuum source, a microvacuum chamber is formed in a gap region centered on the first aperture and extending between the probe surface and the work surface of the object.

118. The vacuum arc tool of claim 117, further comprising:

a second outlet in the support platform at a location removed from the first plate electrode, the second outlet oriented toward the work surface,

wherein the control circuit is further configured to cause a fluid material to flow through the second outlet into the space between the second electrode and the object.

119. A material removal system for removing loose material from an object, the material removal system comprising:

a probe surface oriented toward a surface of the object;

a first annular outlet in the probe surface;

an annular inlet in the probe surface surrounding and substantially concentric with the first annular outlet;

a second annular outlet in the probe surface surrounding and substantially concentric with the annular inlet;

a first remote inlet in a surface of the probe base other than the probe surface, the first remote inlet connected to the first annular outlet by a first duct;

a second remote inlet in a surface of the probe base other than the probe surface, the second remote inlet connected to the second annular outlet by a first duct; and

a remote outlet in a surface of the probe base other than the probe surface, the remote outlet connected to the annular inlet by a third duct,

wherein the probe surface is stepped such that a distance between the first annular outlet and the work surface is less than a distance between the annular inlet and the work surface,

and the distance between the annular inlet and the work surface is less than a distance between the second annular outlet and the work surface,

wherein a low pressure, high viscosity first gas flows through the inner annular outlet toward the object surface, thereby creating a gas bearing and sealing off a region of the probe surface surrounded by the first annular outlet,

wherein a high pressure, low viscosity second gas flows through the outer annular outlet toward the object surface, displacing the loose material, and

wherein the annular inlet draws both the first gas and the second gas away from the probe surface.

120. A method of creating a microvacuum chamber between a probe surface having a first aperture therein and a work surface, the probe surface oriented toward the work surface, the method comprising:

placing a vacuum source in fluid communication with the first aperture at a side of the probe surface oriented away from the work surface;

operating the vacuum source; and

adjusting a gap between the probe surface and the work surface so that an ambient gas between the probe surface and the work surface has a viscous character, the viscous character causing the flow of the ambient gas into a region between the probe surface and the work surface surrounding the first aperture to be restricted.--